CHAPS II: Experimental Planning

Larry Berg[1], Carl Berkowitz[1], John Ogren[2], Chris Hostetler[3], and Rich Ferrare[3]

[1] Pacific Northwest National Laboratory

[2] NOAA Earth System Research Laboratory

[3] NASA Langley Research Center

ASP Science Team Meeting

Boulder, Colorado

Outline

- General sampling strategy
- Instrument lists
- Flight Patterns
- Sampling issues
  - Number of clouds
  - Time in cloud
  - Identification of air that has been processed by clouds

General Sampling Strategy

- Optical properties: Dual air stream
  - Two inlets used during cloud penetration
  - Counter Flow Virtual Impactor (CVI)
    - Selectively samples cloud drops
  - Standard inlet
    - Samples all aerosols
  - Identical instrumentation
  - Fast response, ~1 Hz
- Aerosol composition: Standard inlet
  - Slower response instruments
  - Detailed size and composition
- NASA King Air flying above the G-1

Sampling Issues

- Statistical approach
  - Sample clouds along a horizontal leg
  - No need to sample the same cloud repeatedly
- Two related issues
  - How many clouds?
  - How long in a single cloud?
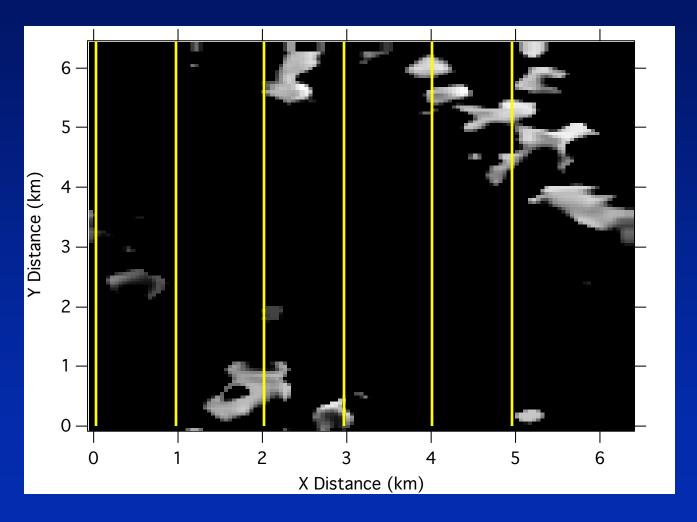- How to identify air that has been processed

LES of Fair Weather Clouds

- ## LES of cloud field
  - 128 x 128 x 128 grid
  - $\Delta X = \Delta Y = 50$ m
  - $\Delta Z = 40$ m
- ## Fair weather GEWEX GCSS study (Brown et al. 2001)
  - Based on conditions from ARM Central Facility
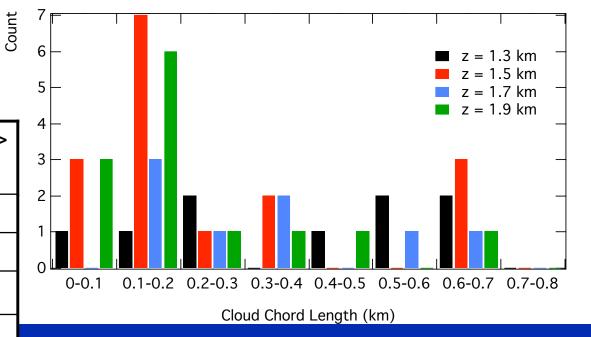
LES Cloud Field

Z = 1.3 km

Cloud fraction = 10%

Simulation courtesy of M. Ovtchinnikov

Sample Histograms

- ## Track cloud chord lengths along each leg
  - ### Used two time periods ~ 70 km long leg

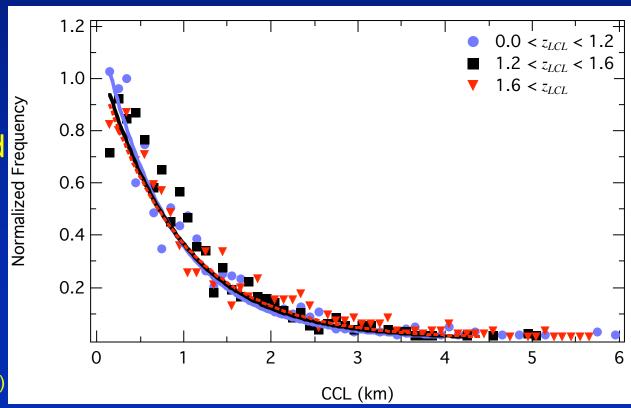| Z (km)	# Chords	# Chords > 0.3 km
1.3	9	5
1.5	16	5
1.7	8	4
1.8	13	4

How Long in a Cloud

- Cloud Chord Length (CCL) can be determined from instruments at ARM Central Facility
    - Cloud radar, lidar, radar wind profiler
    - Samples cloud field like an aircraft

- Mean CCL ~1 km

- Approximately 60% of observed chord lengths greater than 0.5 km

Legend:
- $0.0 < z_{LCL} < 1.2$
- $1.2 < z_{LCL} < 1.6$
- $1.6 < z_{LCL}$

Y-axis: Normalized Frequency
X-axis: CCL (km)

From Berg and Kassianov (2005)

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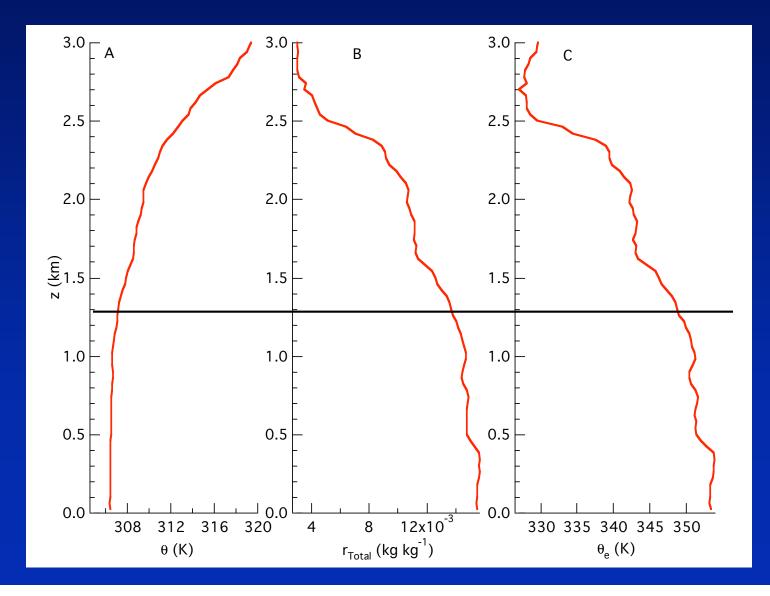
Identification of Cloud Processed Air

- Thermodynamic tracer of opportunity
- Variables that are conserved for dry and moist adiabatic processes
  - As air parcels rise, these values do not change
  - Equivalent potential temperature (θ_e)
    - $\theta_e = \theta \ \exp[L_v \ r_s \ / \ (C_p \ T)]$
  - Total water mixing ratio (r_{Total})
    - Water vapor + cloud water
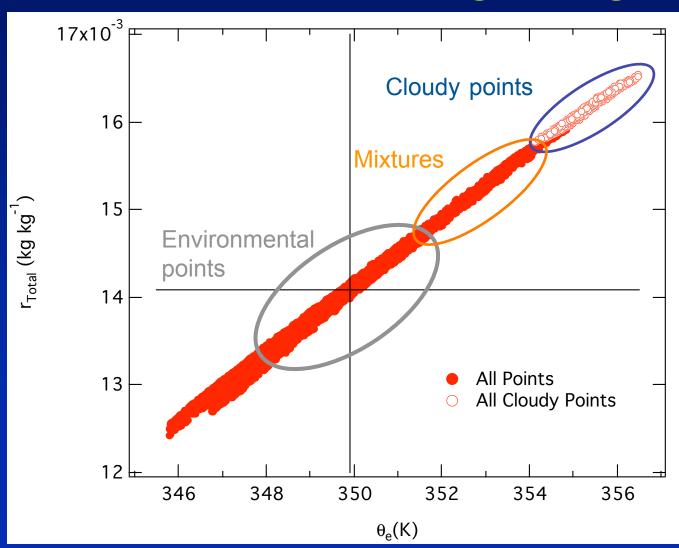- Similar analysis has been done looking at mixing in clouds
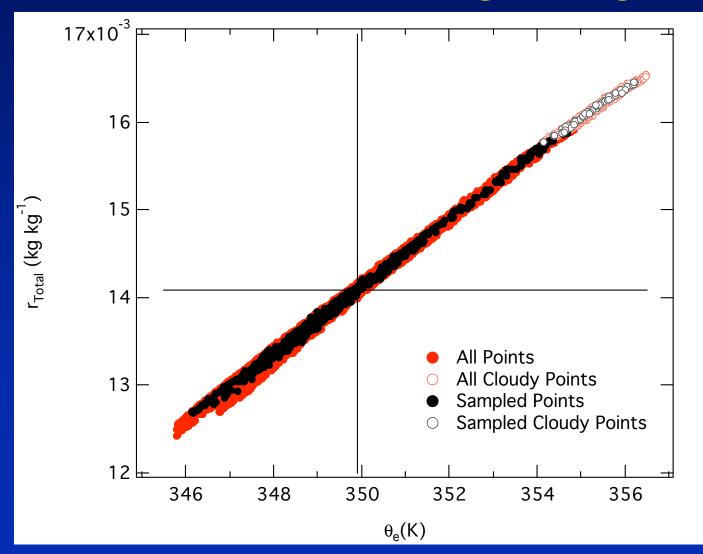
LES Sample Profiles

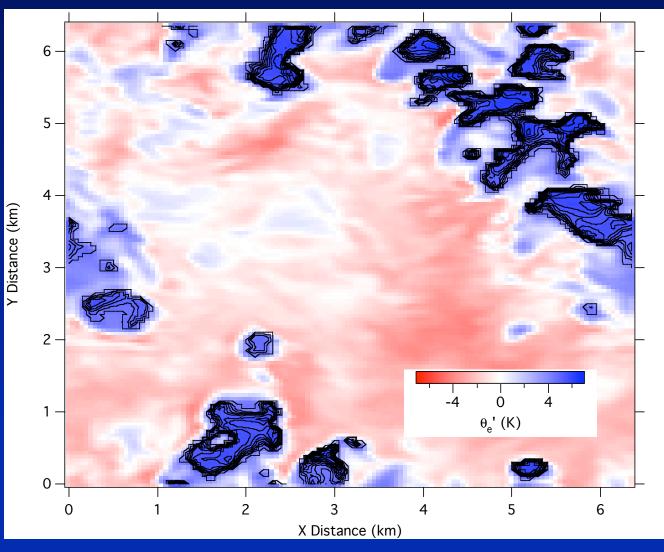# Sample LES Mixing Diagram

Z = 1.3 km

Sample LES Mixing Diagram

Sample LES Clouds

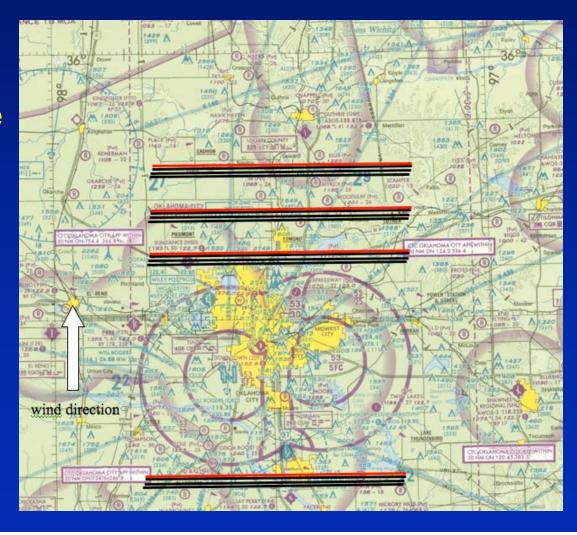Z = 1.3 km   Contour = cloud water

Conclusions

- Instrument list
- Flight pattern
- Issues
  - Number of clouds
  - Length of time in clouds
  - Identification of air that has been processed by clouds

Flight Pattern: A Statistical Study

- G-1
  - Stacks of three legs
  - Below, in and above clouds
- NASA King Air
  - Single altitude above G-1
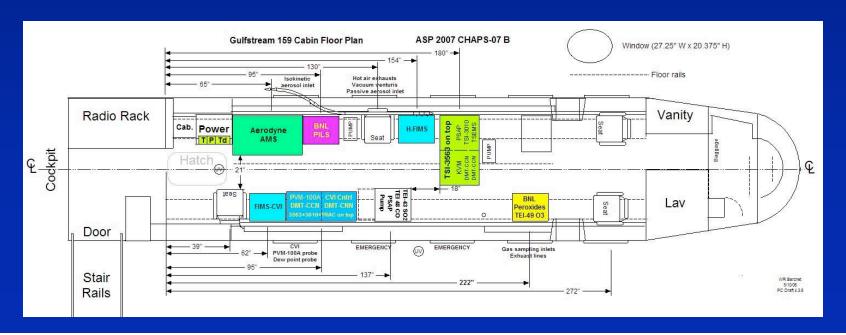- Preliminary okay from FAA

wind direction

Instrument List: Dual Air Stream

- Aerosol scattering; Nephelometer
- Aerosol absorption; PSAP, LAPA
- CCN counters
  - Two per inlet

- Time-resolved aerosol collector
  - Single particle collection
- Water Vapor
- Aerosol size; Fast integrated mobility spectrometer
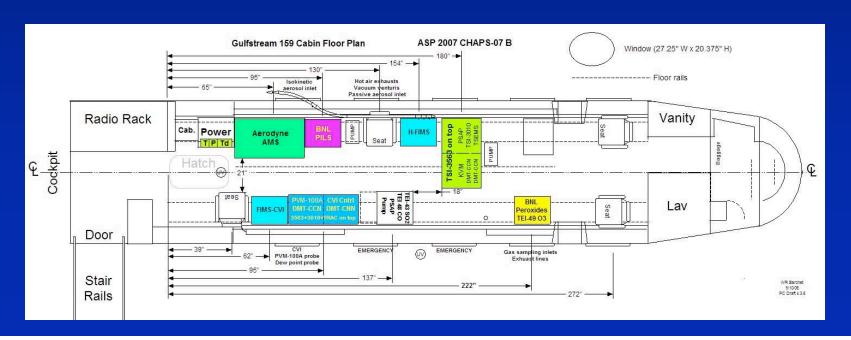- Particle number

Gulfstream 159 Cabin Floor Plan   ASP 2007 CHAPS-07 B

Instrument List: Aerosol Composition and Size

- Hygroscopicity; H-FIMES
- Size
  - SMPS; 0.1 - 3 µm
  - PCASP; 0.17-3 µm
  - CAPS; 0.5-50 µm

- EC Mass
  - DMT Particle Soot Photometer
- Bulk composition; AMS
- Particle ionic composition; PILS

Instrument List: Gas Chemistry

- CO
- SO$_2$
- O$_3$
  - NOAA B2B System
- H$_2$O$_2$